

What is claimed is:

- 1 1. A multi-layer hard mask structure, comprising:
2 a first hard mask layer composed of a first boro-
3 silicate glass layer and an overlying first
4 undoped silicon glass layer; and
5 at least one second hard mask layer disposed on the
6 first hard mask layer, which is composed of a
7 second boro-silicate glass and an overlying
8 second undoped silicon glass layer.
- 1 2. The hard mask structure as claimed in claim 1,
2 wherein a doping concentration of the first boro-silicate
3 glass layer is substantially equal to that of the second
4 boro-silicate glass layer.
- 1 3. The hard mask structure as claimed in claim 2,
2 wherein the doping concentration of the first boro-silicate
3 glass layer is about 4×10^{17} to 8×10^{17} atom/cm².
- 1 4. The hard mask structure as claimed in claim 2,
2 wherein the first boro-silicate glass layer has a thickness
3 of about 0.3 μ m.
- 1 5. The hard mask structure as claimed in claim 1,
2 wherein the first undoped silicon glass layer has a
3 thickness of about 100 to 400Å.
- 1 6. The hard mask structure as claimed in claim 1,
2 wherein the second undoped silicon glass layer has a
3 thickness of about 100 to 400Å.

1 7. The hard mask structure as claimed in claim 1,
2 wherein a doping concentration of the first boro-silicate
3 glass layer is higher than that of the second boro-silicate
4 glass layer.

1 8. The hard mask structure as claimed in claim 7,
2 wherein the doping concentration of the first boro-silicate
3 glass layer is about 4×10^{17} to 8×10^{17} atom/cm².

1 9. The hard mask structure as claimed in claim 7,
2 wherein the doping concentration of the second boro-silicate
3 glass layer is about 1×10^{17} to 5×10^{17} atom/cm².

1 10. A method for etching a deep trench in a substrate,
2 comprising the steps of:

3 forming a multi-layer hard mask structure overlying the
4 substrate, comprising a first hard mask layer and
5 at least one second hard mask layer disposed
6 thereon, wherein the first hard mask layer is
7 composed of a first boro-silicate glass layer and
8 an overlying first undoped silicon glass layer
9 and the second hard mask layer is composed of a
10 second boro-silicate glass layer and an overlying
11 second undoped silicon glass layer;
12 forming a polysilicon layer overlying the multi-layer
13 hard mask structure;
14 etching the polysilicon layer to form an opening
15 therein and expose a portion of the multi-layer
16 hard mask structure;

17 successively etching the multi-layer hard mask
18 structure and the underlying substrate under the
19 opening to simultaneously form the deep trench in
20 the substrate and remove the polysilicon layer;
21 and
22 removing the multi-layer hard mask structure.

1 11. The method as claimed in claim 10, further forming
2 a pad oxide layer and an overlying silicon nitride layer
3 between the substrate and the multi-layer hard mask
4 structure.

1 12. The method as claimed in claim 10, further
2 annealing the multi-layer hard mask structure before the
3 polysilicon layer is formed.

1 13. The method as claimed in claim 12, wherein the
2 annealing is performed at 550 to 600°C.

1 14. The method as claimed in claim 12, wherein the
2 annealing is performed for 15 to 25 minutes.

1 15. The method as claimed in claim 10, wherein a
2 doping concentration of the first boro-silicate glass layer
3 is substantially equal to that of the second boro-silicate
4 glass layer.

1 16. The method as claimed in claim 15, wherein the
2 doping concentration of the first boro-silicate glass layer
3 is about 4×10^{17} to 8×10^{17} atom/cm².

1 17. The method as claimed in claim 10, wherein the
2 first boro-silicate glass layer has a thickness of about
3 0.3 μ m.

1 18. The method as claimed in claim 10, wherein the
2 first undoped silicon glass layer has a thickness of about
3 100 to 400Å.

1 19. The method as claimed in claim 10, wherein the
2 second undoped silicon glass layer has a thickness of about
3 100 to 400Å.

1 20. The method as claimed in claim 10, wherein a
2 doping concentration of the first boro-silicate glass layer
3 is higher than that of the second boro-silicate glass layer.

1 21. The method as claimed in claim 20, wherein the
2 doping concentration of the first boro-silicate glass layer
3 is about 4×10^{17} to 8×10^{17} atom/cm².

1 22. The method as claimed in claim 20, wherein the
2 doping concentration of the second boro-silicate glass layer
3 is about 1×10^{17} to 5×10^{17} atom/cm².

1 23. The method as claimed in claim 10, wherein the
2 polysilicon layer has a thickness of about 0.2 to 0.3 μ m.